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AUTHOR Thompson, David R.
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ABSTRACT

Anticipating a possible future method of newspaper design (including multimedia content) and delivery, a study examined the interface among people, modality (paper, computer, multimedia), and three types of news story (news, sports, entertainment). The "primacy of print" theory (which predicts that information will be recalled better when presented in print than in other media) was extended to consider a multimedia factor. Subjects, 55 undergraduate students enrolled in journalism classes and 20 university library employees recruited as "expert" searchers, completed recall measure after reading and/or listening to news stories presented in a variety of formats. Results indicated (1) no effects for cued recall as a function of modality; (2) a significant effect for reading time as a function of modality, with reading time higher for the multimedia condition followed by computer and paper; (3) story type was a significant factor, with the entertainment story having the shortest reading time followed by news and sports; and (4) the news story had the lowest recall score, followed by sports and entertainment. Findings do not support the primacy of print theory. Future studies may be designed to test interactions between variables such as modality and story type. (Contains 30 references, three tables and eight figures of data, and four notes.) (RS)

THE HUMAN-COMPUTER INTERFACE AND THE NEWSPAPER OF THE FUTURE: SOME COGNITIVE EFFECTS OF MODALITY AND STORY TYPE ON READING TIME AND MEMORY

by

David R. Thompson, Ph.D.

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David R. Thompson, Ph.D.
Mass Communication Department
Southwest Texas State University
San Marcos, Texas 78666
(512) 245-2656
(512) 245-3708 fax

New address as of August 1994:
College of Journalism & Mass Communications
University of South Carolina
Columbia, SC (USA) 29208
(803) 777-4102
(803) 777-4103 fax

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THE HUMAN-COMPUTER INTERFACE AND THE NEWSPAPER OF THE FUTURE: SOME COGNITIVE EFFECTS OF MODALITY AND STORY TYPE ON READING TIME AND MEMORY

ABSTRACT

This paper anticipates a possible future method of newspaper design and delivery. Some newspapers may include multimedia content -- computer-based information that includes audio and video presented by interactive technology systems. Using an experimental approach, this paper examines the interface between people, modality (paper, computer, multimedia), and three types of news story (news, sports, entertainment).

This experiment applied the "primacy of print" theory which predicts that information will be recalled better when presented in print than in other media. This paper extended that theory to consider a multimedia factor.

Findings did not support the primacy of print theory. No effects were found for memory (cued recall) as a function of modality.

However, a significant effect was found for reading time as a function of modality. Reading time was higher for the multimedia condition, followed by computer and paper.

Also, story type was a significant factor. The entertainment story had the shortest reading time, followed by news and sports. The news story had the lowest recall score, followed by sports and entertainment.

Further research of the cognitive effects of multimedia news presentations is encouraged.

INTRODUCTION

This study anticipates a possible future method of newspaper design and delivery. New computer and telephone technologies have made it possible to conceive of newspapers as computer-based information delivery systems that include audio and video presented by interactive technology systems.

Multimedia technology is here and in use.[1] But, as researchers, we must ask: Is it better?

This study applied cognitive psychology, psychology of reading, educational psychology, information science and human factors (study of the human-computer interface) to mass communication research. This study intended to advance theoretical understanding of the communication process.

This study examined the interface between people, mass communication messages, and medium of presentation. An experimental approach was used to search for evidence of a possible cause-and-effect relationship between presentation format and cognitive performance of the reading process.

This experiment applied the "primacy of print" theory. This theory states that information will be recalled better when presented in print (ink-on-paper) than when presented in other media.

This paper extended the primacy of print theory to consider combinations of media. The multimedia condition used in this paper combined computer, video and audio media.

This experiment compared reading ink-on-paper to reading a computer screen to reading and viewing a multimedia presentation. The unit of analysis was the news story.

The independent variable was presentation format (paper, computer, multimedia). Presentation format will be referred to as modality. Another variable included in the experimental design was story type (news, sports, entertainment). Story type was included as a control factor -- to control for prior knowledge of content domains.

The dependent variables for this experiment were reading time and memory (cued recall).

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[1] Multimedia is a system that "supports data other than text" (Nelson 1991, p. 3). Multimedia is sometimes called "hypermedia." The two terms are used interchangeably in this paper.

This research applied existing technology to investigate future implications for 1) publishers who are adapting to electronic technology, including multimedia, 2) consumers who are adjusting to new media in order to obtain the most recent news, and 3) researchers who are seeking to develop cognitive models for design and use of interactive media.

Results of this empirical study may be applied to decisions regarding design, marketing, and feasibility of both print publishing and electronic publishing.

LITERATURE REVIEW AND HYPOTHESES

Although some studies that compare reading print to reading a computer screen have found longer reading times for computer reading (Reinking & Bridwell-Bowles, 1991; Gould & Grischkowsky, 1983; Hansen, Doring, & Whitlock, 1978; Kruk & Muter, 1984; Muter, Latremouille, Treurniet, & Beam, 1982), this study examined short items. Therefore, no difference in reading time was predicted between paper and computer modalities. This supported Oborne & Holton (1988), Switchenko (1984), Fish & Feldman (1987), and Reinking (1988).

To date, the author's literature review has failed to disclose studies on reading time for multimedia.

To test for main effects for modality on reading time (e.g., time spent with the story, including viewing the digitized "movie"), This experiment predicted:[2]

> **H1** A significant main effect will exist for modality based on time spent with the stories (for convenience, this will be referred to as a "reading time" measure). Reading time will be longer for the multimedia condition. And, the computer and paper conditions will have nearly equal reading times.

The act of selecting and viewing the QuickTime[3] movie (digitized audio and video sound bite) may result in increasing reading times for the multimedia condition. The question was:

> **R1** Do subjects choose to watch the video?

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2 H = Hypothesis; R = Research question

3 For this study, digitized audio and video is enabled by QuickTime by MacIntosh. QuickTime is an extension to Apple's System 7.0 or System 6.0.7.

QuickTime movies run at about 15 frames per second whereas full-motion video runs at 30 fps (Don 1992).

Empirical evidence from previous studies demonstrated a consistent superiority on memory tasks for information presented in a print modality (DeFleur, Davenport, Cronin, & DeFleur, 1992; Furnham, Benson, & Gunter, 1987; Furnham & Gunter, 1985, 1989; Furnham, Proctor, & Gunter, 1988; Gunter & Furnham, 1986; Gunter, Furnham, & Gietson, 1984; Gunter, Furnham, & Leese, 1986; Rice, 1990).

Some of these studies have tested print vs. aural presentations; some of these studies have tested print vs. computer presentations.

To date, the author's literature review has failed to disclose studies of multimedia effects on recall.

To test for main effects for modality on recall, This experiment predicted:

> **H2** A significant main effect will exist for modality based on performance of a cued recall task (multiple choice questions). Recall will be better for the paper modality, followed by computer and multimedia in that order.

No directional hypotheses were constructed for story type. However, significance tests will determine whether or not a main effect exists for story type. Statistical tests also will determine patterns in performance among levels of the story type variable for reading time and recall. This study asked:

> **R2** Does a significant main effect exist for story type on reading time? What story type results in the shortest reading times? longest reading times?
>
> **R3** Does a significant main effect exist for story type on recall? What story type is remembered best? worst?

No directional hypotheses have been constructed for order. However, significance tests will determine whether a main effect exists for order. This study asked:

> **R4** Does a significant main effect exist for order on reading time? What order (combination of modalities with story types) yields the shortest reading times? the longest?
>
> **R5** Does a significant main effect exist for order on recall? What order is associated with the best recall scores? the worst?

METHOD

Experimental Design

A randomized 3 X 3 Latin Square design was used. The cells of the Latin Square were constructed by combining modality (paper, computer, multimedia) and story type (news, sports, lifestyle). The rows of the Latin Square were treated as experimental orders.

Figure 1. The Latin Square design

Order 1	C + N	P + S	M + E
Order 2	P + E	M + N	C + S
Order 3	M+ S	C + E	P + N

Modality	Story Type
P = Paper	N = News
C = Computer	S = Sports
M = Multimedia	E = Entertainment

This design provides a foundation for discovery of main effects. However, because the exerimental design is not fully factorial, the Latin Square includes a "designed confound" that makes it impossible to reliably detect interactions between variables.

Analysis of the data will reveal main effects for each independent variable (for example: Does a significant main effect exist for modality?). Analysis of variance will be used for this analysis.

Then, analysis will examine effects between levels of an independent variable (for example: Does a significant difference exist between the paper and computer modalities for reading time?). Contrasts, or focused F-tests are performed for this analysis.

This Latin Square was treated as a within-subjects design. Each subject saw each modality and each story type. The orders determined the combination of story type and modality to which each subject was exposed, and subjects were randomly assigned to orders.

The independent variables were modality and story type. Order was also a factor. The dependent variables were reading time and recall.

Reading time was recorded (in seconds) by stopwatch.

Cued recall was operationalized by a series of multiple choice questions on the content of each story. For example, each subject read a story about a shipwreck and oil spill. One question was: How forceful are the winds that prevent cleaning up the oil spill? a) 45 mph, b) 55 mph, c) 65 mph, d) 75 mph, e) 85 mph. As read in the story, the answer to this question was "c) 65 mph."

Five, 5-choice questions were asked about each story. The recall score was the number of correct responses.

Subjects

Seventy-five individuals participated in this study. Fifty-five of those were U.S. undergraduate students enrolled in journalism classes who participated for course credit. Twenty subjects were university library employees, recruited as "expert" searchers (necessary for the design of a related study). These subjects volunteered their time. All subjects were debriefed about the purposes of the study afterwards.

Materials

A selective sample of stories was used in order to accommodate the multimedia condition. The multimedia condition required a short (5-8 second) "sound bite." This method was used to avoid the expense of producing news stories.

The source of the stories was CNN "Headline News," January 10-14, 1993 (Sunday - Thursday). Three stories from a sample of 48 were selected -- one for each story type (news, sports, entertainment). Stories considered for selection included enough information to write a 180-word print story and had a 5-8 second audio-video segment that could stand alone as a sound bite.

Following Oborne & Holton's (1988, pp. 4-5) suggestions for experimental controls, stimulus materials used in this paper were written by the researcher. See Figure 2 for an example

of a story layout used in this experiment. Each story unit included a headline, text, photo, and photo caption. This story format was based on a review of mass communication literature (Bain, 1980, p.2; Pasternack & Utt, 1986, p.33; Pipps, 1985, p. 1; Van Nes, 1986, pp. 116-117; Barnhurst, 1991, pp.21-22; Tinker, 1966, p. 169; Matazzoni, 1992, pp. 18-19; Kolers, Duchnicky, & Ferguson, 1981, p. 525; Dillon, Richardson, & McKnight, 1990, p. 224).

All stories were the same length, about 180 words. All stories were tested for equivalence in readability. Story format and size were held constant across all stories and modalities -- except when multimedia brought the images to life with video and audio

One story per page or computer screen was used. Page turns and "jumps" to another page were considered confounding variables and were avoided in this research. A landscape (horizontal, 11 x 8-1/2) format was used. The story was set in three columns -- two even columns of text with the image and caption in the third, right-hand column.

Headline type was set flush left/ragged right in 30-point Helvetica bold. Body type was set flush left/ragged right in 12-point Palatino. Caption type was set flush left/ragged right in 10-point Palatino. Upper- and lower-case letters were used. And, the layout used included ample white space, so the page and screen were not filled with text.

Pictures (four-color process) and graphics windows were placed in the same location on the page and were the same size. This minimized confounding between experimental conditions.

To construct the multimedia conditon, the video clip was digitized for storage as a computer file. The video was captured on VHS tape. The video output of the videocassette recorder was plugged into a video spigot card on a Macintosh computer. The VHS audio output was plugged into the built-in audio input on a Macintosh Quadra 950.

The application Screen Play was used to record the video clip and save it on the computer. Then, the QuickTime Movie Player application was used to edit the digitized videos. The edited videos were then saved as self-contained QuickTime movies.

The digitized video files were not compressed. This avoided degradation of the quality of the images.

Figure 2. An example of the stories used as stimulus materials

Dolly Wins CMA Award

Dolly Parton was the guest of honor Wednesday at the Country Music Association's award ceremony. Parton received the Country Music Honors Award. This is the first time such an award has been given.

The singer and sometime actress was cited for her outstanding achievements and upstanding character.

"This is a dream come true. I don't believe it. I'll take it, but I don't believe it," Parton said as she accepted the award.

"No one deserves it more," Loretta Lynn said.

Garth Brooks, Tammy Wynette, Randy Travis and K.T. Oslin were on hand to congratulate Parton.

Parton said, "This deserves a celebration. The rides are free tomorrow at Dollyland." Dollyland is Parton's theme park near her hometown of Daleville, Tennessee.

The event was held at the Grand Ole Opry in Nashville. CBS broadcast the event.

One viewer in Parton's hometown, Daleville, said, "It's about time. Dolly has done a world of good for herself and her fans. We just love her to death around here."

Dolly Parton appears in the movie "Straight Talk."

11

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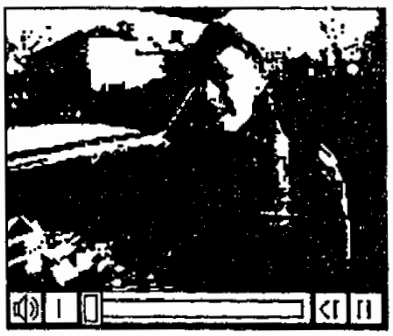
Each video was then stored in a separate file on a reloadable hard disk. A HyperCard command loaded the proper image or video into each story as needed.

HyperCard allowed the use of hypertext linkages. Hypertext is "a computer-based system that allows immediate, nonsequential access to linked items of information" (Marmion 1990, p. 7).

The research conducted for this paper does not test hypertext. However, the linkage between information nodes[4] applied in hypertext provides a foundation for multimedia applications.

A story template in HyperCard determined the size and placement of the image. The video clip appeared as a still frame. This was actually the first frame of the QuickTime movie. A "play" icon (a thin vertical bar near the botton left-hand corner) appeared in the QuickTime control strip at the bottom of the image. A click of the mouse on this button activated the video. The subject controlled this interactive device.

Figure 3. Movie control bar used to activate the QuickTime movie in the multimedia condition



This was the multimedia condition.

The computer condition was the same -- except there was no video control strip. The same still image that was the first frame of the video served as a photograph in the computer condition.

The paper condition was the same as the computer condition -- except it was a high-quality color laser print.

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4 Slatin (1990, p. 877) defines link and node. "Linkage, in hypertext, plays a role corresponding to that of sequence in conventional text. ... A node is any object which is linked to another object."

Apparatus

The multimedia and computer conditions were presented on a Macintosh iiCI with 16-bit color using System 7 and QuickTime extensions.

The QuickTime movies were digitized from VHS videotape using a videocassette recorder and a Macintosh Quadra. Two Cyquest drives were used to accommodate the reloadable hard disks required to store the video clips.

The paper condition was produced by printing the computer condition using an Apple color laser printer.

Hypercard was used to program the experimental orders and control the images and movies.

Each experimental session was recorded on videotape as a backup for coding, and a stopwatch was used to clock reading times and search times.

The recall task (five, 5-choice questions per story) was a pencil-and-paper instrument.

Procedure

After signing a Consent Form, the subject was directed toward three different news stories (one per story type -- news, sports, entertainment). Each story was presented in a different modality (paper, computer, multimedia).

Determined by experimental order, the experimenter told the subject which story to read first, second, and third.

The word "read" was avoided as much as possible in the instructions to avoid biasing the subject toward the text. The subject controlled starting the video. The word "read" might otherwise have pre-empted any motivation to "view."

To clock reading time, the experimenter said "Go" to indicate when the subject should begin a story. A stopwatch was activated. The subject was instructed to say "Stop" when finished with the story. The stopwatch was then stopped and the time recorded on paper by the experimenter.

A sample story was provided. The subject was informed about the possible presence of the QuickTime movie. The subject practiced starting the video. A practice session was conducted, including sample recall questions.

The subject was told the number of correct responses. Then, the subject had an opportunity to ask questions.

The experiment began. After exposure to the three stories, a short distractor task was administered. The distractor task asked for the subject's gender, ethnicity, and age. Then, the recall task was administered.

This concluded the experiment.

RESULTS

SPSS (version 4.0) was used for the data analysis.

Analyses of variance were used to analyze the results of This experiment. The analysis of variance tested for main effects. This allowed the researcher to make statements such as: The effect of modality on reading time was [this].

"Contrasts" were run to test differences between the levels of the experimental factors. A Contrast is a focused F-test that allowed the researcher to specify a specific hypothesis to compare one set of means versus another set of means. Contrast is a one degree of freedom F-test performed from within the ANOVA. This allowed the researcher to make statements such as: The paper modality was significantly different than the computer modality for effects on reading time. Contrasts have been reported in tables as "[this level of a variable] vs [that level of a variable]."

Did the subjects choose to watch the QuickTime movie?

A successful interactive newspaper of the future will have readers who use the multimedia features.

The question (R1) was: Do subjects choose to watch the video?

Results showed that 52 of the 75 subjects chose to view the QuickTime (digitized) movie. That is, 69 percent of the subjects saw the video.

The act of selecting and viewing the QuickTime movie resulted in increasing reading times for the multimedia condition.

Reading time as a function of modality

This study predicted:

> **H1** A significant main effect will exist in modality based on time spent with the stories (for convenience, this will be referred to as a "reading time" measure). Reading time will be longer for the multimedia condition. And, the computer and paper conditions will have nearly equal reading times.

Results of this study support H1. For reading time, a main effect was found for modality ($F(2) = 39.87$, $p < .001$). Mean reading times by modality were, as predicted, highest for the multimedia condition ($M = 59.77$). The reading times for paper ($M = 48.20$) and computer ($M = 49.75$) were nearly equal. (See Table 1 and Figure 4.)

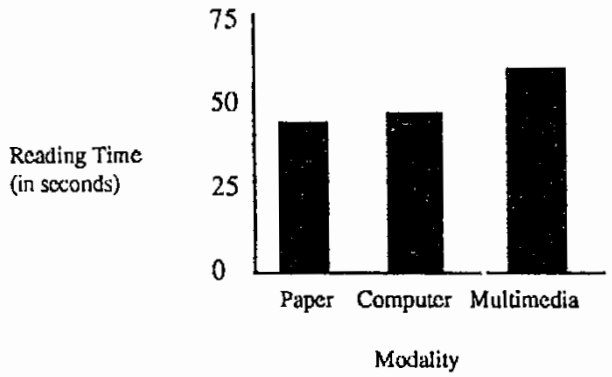
Consistent with findings reported in the literature review, no significant difference was found for reading times between the paper and computer modalities ($F(1) = 1.25$, $p > .05$), but there were significant differences in reading times between the paper and multimedia conditions ($F(1) = 67.77$, $p < .001$) and between the computer and multimedia conditions ($F(1) = 50.60$, $p < .001$).

Table 1. Results of ANOVA and Contrasts for reading time as a function of modality

Variable	Mean	MS	df	F
MODALITY		2923.80	2	39.87***
Paper	48.20			
Computer	49.75			
Multimedia	59.77			
Paper vs Multimedia		4969.16	1	67.77***
Computer vs Multimedia		3710.49	1	50.60***
Paper vs Computer		91.75	1	1.25

*$p < .05$
**$p < .01$
***$p < .001$

Figure 4. Means for reading time as a function of modality



Recall as a function of modality

To test for main effects for modality by recall, This experiment predicted:

H2 A significant main effect will exist for modality based on performance of a cued recall task (multiple choice questions). Recall will be better for the paper modality, followed by computer and multimedia in that order.

Five 5-choice recall questions were asked about each story. The recall score for a particular story was operationalized as the number of correct responses for questions about that story. In other words, the possible range of recall scores was zero to five. Results of pre-testing the recall questions showed no ceiling or floor effects.

As an example, the text of the news story, "Winds hamper Shetland clean up," read:

Scottish and British oil clean-up crews have been hampered by 65 mph winds. As they look on, a wrecked tanker ship is battered into three pieces against the Shetland Islands shoreline.

The ship crashed against the Scottish shore nine days ago. It was carrying over 24 million gallons of crude oil at the time of the wreck. Now, over half that cargo has poured into the sea, experts said.

One question asked: How forceful are the winds that prevent cleaning up the oil spill?

a) 45 mph, b) 55 mph, c) 65 mph, d) 75 mph, e) 85 mph.

The correct answer is "c) 65 mph."

Results of this study did not support the primacy of print theory. No main effect was found for recall as a function of modality ($F(2) = 1.24$, $p > .05$).

The paper modality was not better remembered. Evidence reported by this study indicated slightly better recall for the multimedia condition ($M = 3.51$), followed by computer ($M = 3.31$) and paper ($M = 3.24$) in that order.

Because no main effect was found, contrasts between levels of the modality variable were not appropriate and were not conducted.

Reading time as a function of story type

This study asked:

R2 Does a significant main effect exist for story type on reading time? What story type results in the shortest reading times? longest reading times?

Results showed a significant main effect for reading time as a function of story type ($F(2) = 3.10$, $p < .05$). (See Table 2.)

The entertainment story ($M = 50.52$) had the shortest mean reading time, followed by news ($M = 53.00$) and sports ($M = 54.20$) in that order. (See Figure 5.)

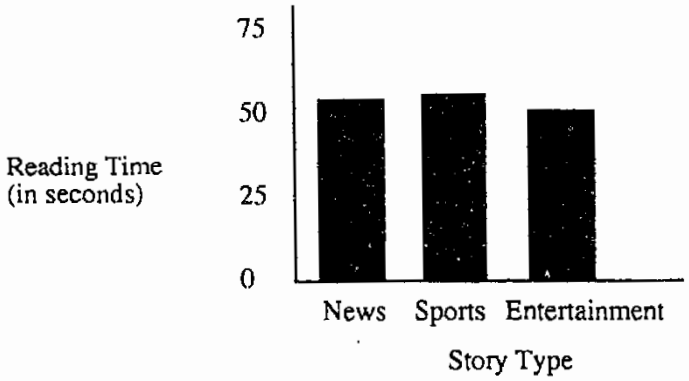
One significant difference was found between levels of the story type factor. The difference was found between the sports and entertainment stories ($F(1) = 5.89$, $p < .05$).

Table 2. Results of ANOVA and Contrasts for reading time as a function of story type

Variable	Mean	MS	df	F
STORY TYPE		227.11	2	3.10*
News	53.00			
Sports	54.20			
Entertainment	50.52			
News vs Entertainment		210.20	1	2.87
Sports vs Entertainment		431.69	1	5.89*
News vs Sports		39.42	1	.54

* $p < .05$
** $p < .01$
*** $p < .001$

Figure 5. Mean reading time scores as a function of story type



Recall as a function of story type

This study asked:

R3 Does a significant main effect exist for story type on recall? What story type is remembered best? worst?

A significant main effect was found for recall as a function of story type ($F(2) = 9.72$, $p < .001$). (See Table 3.)

The entertainment story had the better recall score ($M = 3.81$), followed by the sports story ($M = 3.17$) and the news story ($M = 3.07$) in that order. (See Figure 6.)

Significant differences were found for recall between the news and entertainment stories ($F(1) = 16.52$, $p < .001$) and between the sports and entertainment stories ($F(1) = 12.32$, $p < .01$).

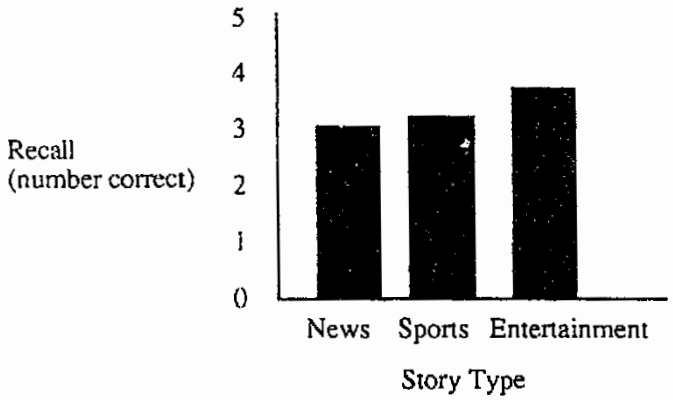
No difference was found for recall between the news and sports stories.

Table 3. Results of ANOVA and Contrasts for recall as a function of story type

Variable	Mean	MS	df	F
STORY TYPE		12.36	2	9.72***
News	3.07			
Sports	3.17			
Entertainment	3.81			
News vs Entertainment		21.02	1	16.52***
Sports vs Entertainment		15.67	1	12.32**
News vs Sports		.39	1	.31

* $p < .05$
** $p < .01$
*** $p < .001$

Figure 6. Mean recall scores as a function of story type



Reading time as a function of modality by story type

Although no interactions could be tested for significance, an interactive "map" could be shown in graphic form.

This "map" depicts the relative position of results for combinations of modality and story type as measured by reading time. This depiction may serve as a baseline for comparison of future studies that use fully factorial experimental designs.

For reading time as a function of modality by story type, the following figure was constructed.

Figure 7. Reading time as a function of modality by story type

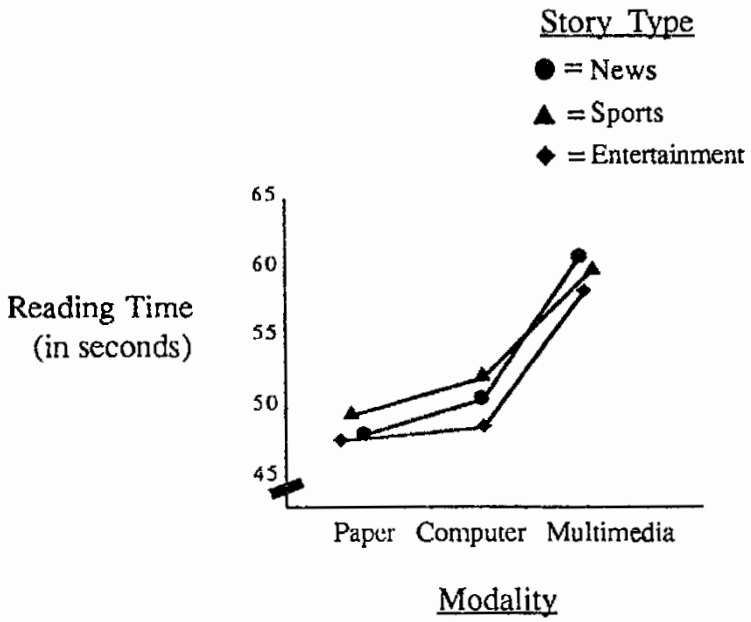


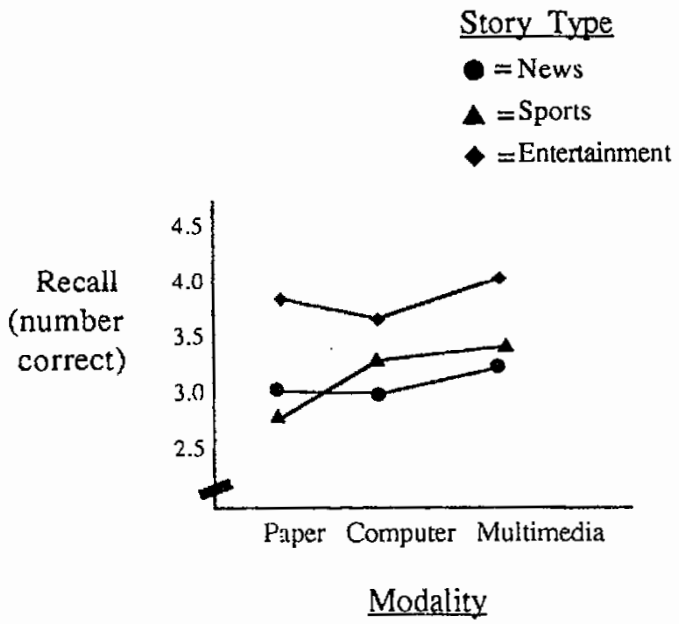
Figure 7 demonstrates that, for reading time as a function of modality by story type, sports stories presented with multimedia break from the pattern by having a relatively lower reading time than sports stories presented with other modalities.

In paper and computer modalities, sports stories have the longest reading times. Yet, in the multimedia condition, sports stories have the second longest reading times (surpassed by news stories).

Recall as a function of modality by story type

The following figure depicts the relative position of results for combinations of modality and story type as measured by recall. This depiction may serve as a baseline for comparison of future studies that are designed to test for interactions.

Figure 8. Recall as a function of modality by story type



For recall as a function of modality by story type, Figure 8 demonstrates that the entertainment story consistently had the highest recall scores. The sports story moved from the lowest recall scores in the paper condition to the second lowest recall scores for both the computer and multimedia conditions.

Reading time as a function of experimental order

This study asked:

R4 Does a significant main effect exist for order on reading time? What order (combination of modalities with story types) yields the shortest reading times? the longest?

Order #1 included the following combinations of story type and modality: news + computer, sports + paper, and entertainment + multimedia.

Order #2 included the following combinations of story type and modality: news + multimedia, sports + computer, and entertainment + paper.

Order #3 included the following combinations of story type and modality: news + paper, sports + multimedia, and entertainment + computer.

Subjects were randomly assigned to experimental order.

For reading time as a function of order, no main effect was found ($F(2) = .29$, $p > .05$).

Differences in mean reading times across the three orders appeared to be small. Mean reading times showed the shortest reading time for Order #3 ($M = 51.71$), followed by Order #1 ($M = 52.75$) and Order #2 ($M = 53.30$).

Contrasts between pairs of levels of the order factor as measured by reading time are not appropriate since no main effect was found.

Recall as a function of experimental order

R5 Does a significant main effect exist for order on recall? What order is associated with the best recall scores? the worst?

No main effect was found for recall as a function of order ($F(2) = 1.03$, $p > .05$).

The differences in means for order by recall appear small. Order #3 had the higher recall score ($M = 3.73$), followed by Order #2 ($M = 3.45$) and Order #1 ($M = 3.26$).

No contrasts were conducted because there was no main effect.

DISCUSSION

The newspaper of the future may use interactive multimedia systems to present mass communication content. How will this affect the reader and viewer? Will information presented in a multimedia format be remembered better than information presented on paper or on a computer screen without audio and video?

This study applied the primacy of print theory, which predicts that information presented in print will be better remembered than information presented by other modalities. The results of this experiment did not support the primacy of print theory. No effects were found for recall as a function of modality.

Furnham, Proctor, & Gunter (1988, p. 935) suggested that self-pacing and depth of processing were possible explanations for better recall of information presented on paper.

This researcher suggested that the multimedia condition involved an aspect of self-pacing. The subject had control over if, when, and how frequently the video was played.

The multimedia condition also involved a combination of text, video, and audio. The subject even had to become physically involved in the multimedia condition -- by clicking the mouse to begin the video. These aspects of the multimedia condition increased involvement with the medium.

These points suggest that recall could be enhanced by the multimedia condition. Yet, no significant difference was found for recall as a function of modality. No significant differences were found between any levels of modality for recall.

Was the recall test valid and reliable?

Pre-tests of the recall questions found no ceiling (consistently high scores) or floor effects (consistently low scores). Five-choice questions were used to lower the chances of guessing the correct answers.

During the experimental session, some subjects mentioned that the questions were difficult.

The same measures found no difference for one variable and a significant difference for another variable. Although no differences were found for recall by modality, significant differences were found for recall as a function of story type. This convergent evidence suggests that the recall task was valid and reliable. The recall task used for this paper discriminated effects by independent variables.

The recall score reported in the data analysis is a collective score. It is the total number of correct responses to the questions asked about each story. Five questions were asked for each story. To determine the effectiveness of the recall measure across modalities, further analysis was conducted.

Scatterplots of these collective measures revealed relatively "tight" elliptical distributions for the recall questions in the computer and multimedia conditions. But for the paper condition, the questions about the sports story had a wide distribution.

In addition, the frequency of correct responses for each recall question was examined for each modality. Histograms revealed that the same questions (split by story type) had a similar pattern of correct responses for each modality.

Again, this suggests that the recall task used for this research was reliable and valid. Perhaps some recall effects attributed to modalities in existing literature should be re-examined for possible influence by content.

This research used only a cued recall task (multiple choice questions). Future research may use other measures of memory, such as free recall tasks and recognition tasks to test the findings of this research. Future research may use multiple measures to provide convergent evidence of effects on memory.

The results of this experiment support the literature cited that found "no difference" for reading times between the paper and computer modalities. Yet, a significant difference was found for reading time by modality. The multimedia condition had significantly longer reading times than both the paper and computer conditions.

Could this be an artifact of the time needed to view the video?

In this experiment, 69 percent of the subjects chose to see the video. Each video used for this study had a viewing time of 5-6 seconds. But, the mean viewing time for the multimedia condition was over 10 seconds longer than the mean viewing time for either the paper or computer modalities.

Where did the extra 4-5 seconds come from? Was it time used to decide to watch the video? Was it time taken to physically select the video? Was it time used to re-read the text after seeing the video?

The measures taken during the experimental session did not allow the researcher to determine "decision" time. But, the experimenter observed some subjects make an apparently

conscious effort to reach for the mouse in order to select the video. The experimenter watched these subjects look away from the screen, look at the mouse, reach for the mouse, then look back at the screen to click the movie control bar.

Other subjects held the mouse at all times.

Some subjects read the text, selected the video, then re-read the text (or parts of it).

This suggests a need to design experimental sessions that track these decisions and their subsequent effects on performance of measurement tasks.

Future Research

To confirm the findings of this study and to advance scientific understanding of multimedia news, more research must be conducted.

Future studies may be designed to test interactions between variables such as modality and story type.

The subjects who participated in the research conducted for this paper had little or no experience with the multimedia modality. Subjects who have more extensive training or experience using multimedia information sources may be included in experimental designs. Also, young people who have used multimedia learning tools in classrooms may be included as experimental subjects.

Using this paper as a baseline, studies may be designed that use more extensive information bases. This would allow researchers to expand the scope of reading tasks (beyond the single-screen story).

Other future research may provide subjects with a source of information, whether paper, computer, or multimedia, and watch how the subjects behave. Given control over selection of information, what will subjects choose to use? What do they read or watch? For how long? With what effect?

The future holds many possibilities. Newspapers of the future may apply multimedia technologies to news content. More cross-modality research may be conducted to examine the cognitive, behavioral and subjective effects of exposure to multimedia news sources.

CONCLUSION

Newspapers of the future that include digitized audio and video may find that their readers have little difficulty adapting to multimedia presentations of mass communication messages.

Evidence gathered by research conducted for this paper has shown that people spend more time with multimedia presentations than with paper or computer. Future studies may investigate the reason for this ... was it novelty? motivation, or involvement? or simply the time needed to operate the interactive interface?

Evidence gathered by this research has shown that content does affect people's performance on measurement tasks. To confirm the evidence found here, more studies of story type should be conducted.

Researchers may begin to notice less and less resistance to computerized information delivery systems. Yesterday's students have grown up with television in the home. Today's students are growing up with computers in the home and in the classroom. Tomorrow's media consumers may expect interactive multimedia systems to deliver news and information.

Work must begin now in order to meet future expectations of efficient and effective interactive multimedia systems and content.

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